DBP: TRIHALOMETHANES

FACT SHEET

See related Fact Sheets: Acronyms & Abbreviations; Glossary of Terms; Cost Assumptions; Raw Water Composition; Total Plant Costs; and WaTER Program.

1. CONTAMINANT DATA

A. Chemical Data: Trihalomethanes (THMs) are formed during the disinfection process when a chlorine-containing disinfectant combines with organic matter in the water, forming a disinfection by-product (DBP). THMs are one of a family of organic compounds named as derivatives of methane. There are four common THMs: trichloromethane (chloroform) - the most common in most water systems, dibromochloromethane - the most serious cancer risk, dichlorobromomethane, and tribromomethane (bromoform). THMs are colorless, volatile, dissolve easily in water, and are fairly stable.

B. Source in Nature: THMs are found naturally in small amounts in most waters. The majority of THMs are anthropogenic. Major sources of THMs in the environment come from bleaching of wood pulp by paper mills and disinfection of drinking water, municipal wastewater upstream of the water treatment plant, and cooling water. They form when chlorine containing compounds/disinfectants react with naturally occurring organic materials such as humic acids from decaying vegetation.

C. SDWA Limits: THMs are one of four regulated DBPs. The MCL for total THMs is 0.08 mg/L (annual average). Significant monitoring requirements are also included in the SDWA regulations. The MCLG is 0.000 mg/L for dichlorobromomethane, 0.000 mg/L for bromoform, and 0.06 mg/L for dibromochloromethane. Future regulations will likely add an MCLG for chloroform of 0.07 mg/L.

D. Health Effects of Contamination: THMs at short-term exposure levels above the MCL have not been shown to cause ill health effects. At long-term exposure levels above the MCL, THMs may cause liver, kidney, or central nervous systems problems, and may cause an increased risk of cancer.

2. REDUCTION and REMOVAL TECHNIQUES

THM control focuses primarily on:
- Removing THM precursors
- Reducing the oxidant demand (e.g. NOM removal), and consequential reduction in dosage applied.
- Source water selection
- Optimization of the Disinfection Process

The removal of THMs is usually a final solution when other methods can not achieve required reductions.

A. USEPA BAT:
<u>NOM Removal</u>
- Enhanced coagulation and media filtration for NOM removal uses the conventional treatment processes of chemical addition, coagulation, and dual media filtration. Benefits: low capital costs for proven, reliable process. Limitations: operator care required with chemical usage; sludge disposal.
- Granular activated carbon (GAC) filters can be used to remove NOM. GAC uses extremely porous carbon media in a process known as adsorption. As water passes through the media, the dissolved contaminants are attracted and held (adsorbed) on the solid surface. Benefits: well established; suitable for home use. Limitations: effectiveness based on contaminant type, concentration, rate of water usage, and type of carbon used; requires careful monitoring.

B. Alternative Methods of Treatment:
<u>NOM Removal</u>
- Enhanced coagulation and microfiltration (MF) or ultrafiltration (UF) for NOM removal uses membrane filtration of coagulated NOM. Benefits: low capital costs for fairly new, but proven process. Limitations: higher operator care than for sand filtration, higher O&M costs.
- Nanofiltration (NF) for NOM removal uses membranes to physically separate the NOM from the water. Benefits: less operator care than with coagulation and microfiltration, consistent low NOM product water. Limitations: membrane fouling, operator care, higher O&M costs than microfiltration, concentrate disposal.
- Reverse osmosis (RO) for dissolved NOM removal uses a semipermeable membrane and high pressure pump to cause the water, but not suspended or dissolved solids NOM to pass through the membrane. Benefits: produces high quality water. Limitations: high cost; membrane fouling, pretreatment/feed pump requirements; concentrate disposal.
- Lime softening uses $Ca(OH)_2$ in sufficient quantity to raise the pH to about 10 to precipitate carbonate hardness and trap NOM in the process. Benefits: lower capital costs; proven and reliable. Limitations: operator care required with chemical usage; sludge disposal. pH readjustment needed.

Source Water Selection
The selection of a source water, when possible, can significantly reduce THM formation. The quantity and type of NOM in the source water impacts the amount of THMs formed. The amount of bromide will affect the amount of brominated THM species formed. The pH can affect the quantity and species of THMs formed.

Optimization of the Disinfection Process
The type and location of disinfection can greatly affect the amount and species of THMs formed. This must always be checked against providing required CT values. When free chlorine is used, moving the disinfection point farther down in the process train will reduce THM formation time. Also, if chlorination is after coagulation, there will be less NOM present to react with. The most common modification of free chlorine to reduce THMs occurs in converting free chlorine to chloramines in the distribution system. Chloramines have a very low THM formation potential and are ideal for maintaining a constant chlorine residual. Changing the disinfection process to ozonation can be very effective in reducing THMs, but it is fairly expensive and there is a problem with bromate and other brominated DBP formation in high bromide waters. Switching to UV disinfection eliminates all THM formation and is less expensive than ozonation. A disinfectant residual using chloramines or free chlorine still needs to be provided in the distribution system for both ozone and UV treatment. Use of chlorine dioxide, a strong oxidant, does not produce significant THMs, but will produce some amount of chlorite, which is a regulated DBP.

THM Removal
- THMs can be removed by adsorption with an activated carbon filter (see “NOM Removal” section above).
- RO is also effective for THM removal (see “NOM Removal” section above).

Point of Use Systems
Solid block or precoated absorption filters made with carbon or activated alumina certified to reduce THMs are available for point of use systems.

C. Safety and Health Requirements for Treatment Processes:
Personnel involved with demineralization treatment processes should be aware of the chemicals being used (MSDS information), the electrical shock hazards, and the hydraulic pressures required to operate the equipment. General industry safety, health, and self protection practices should be followed, including proper use of tools.

3. BAT PROCESS DESCRIPTION AND COST DATA
BAT process description and cost data sheets are located at the end of the DBP section.

General Assumptions: Refer to: Raw Water Composition Fact Sheet for ionic concentrations; and Cost Assumptions Fact Sheet for cost index data and process assumptions. All costs are based on *ENR*, PPI, and BLS cost indices for March 2001. General sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal are not included.

Refer to pages 9 of 12 through 12 of 12 for process descriptions and cost data.

4. REFERENCES

USEPA BAT (Coagulation and GAC):
http://www.epa.gov/safewater/mdbp/stage1dbprwhatdoesitmeantoyou.pdf
USEPA. The Stage 1 Disinfectants and Disinfection Byproducts Rule, What Does it Mean to You. EPA 816-R-01-014. June 2001.

http://www.epa.gov/OGWDW/mdbp/dbpfr.html
USEPA. National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts; Final Rule. RIN 2040-AB82. 40 CFR Parts 9, 141, and 142. Section II E. December 1998.